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LABNET PROJECT PLAN

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LabNet Project Plan

0. Overview

The LabNet Project will provide a high-speed computer communications utility between buildings at the Laboratory that promotes the sharing of resources, yet maintains the security of classified information. Through LabNet, Laboratory programs can meet their data communications needs in a cost-effective manner. The success of the project will be measured by the number of satisfied clients.

To accomplish this, LabNet will furnish two physically separated multichannel data communications media that span the Laboratory. One of these multichannel backbones, called the Closed LabNet, will be suitable for the transmission of classified data; it will be limited, at first, to PARD level. The other, called Open LabNet, will be for unclassified data only. Over the backbone, common-carrier and value-added services can be offered.

LabNet value-added service is a high-speed packet-switched network that ties computers together. From the point-of-view of a single computer, or of a local network of computers within a building or a group of buildings, the LabNet high-speed network is a long-haul network (like Tymnet or ARPANET) for getting to other buildings. This service is provided through channels of the backbone that are shared by everyone at the Laboratory. The focus of the high-speed network is the efficient transfer of data between computers as opposed to the interconnection of people's terminals to these computers. The latter function is best served by the local networks, or by a separate network (see Appendix A).

Like the telephone company, LabNet common-carrier service gives the client a "wire" between buildings that is used in whatever way the client wishes. This service reduces the need for groups to install their own cables between buildings. It is provided by assigning individual channels of the backbone for a client's exclusive use.

To implement LabNet, the backbone medium is broadband coaxial cable, and standard cable-TV components are used to create multiple channels on a single coaxial cable. Individual channels are assigned to clients for the common-carrier service. For the Closed LabNet, existing underground TMDS coaxial cable is used. New cable is being installed for the Open LabNet. The backbone will be augmented with optical fibers in the future.

One pair of channels is used for the high-speed packet-switched network. A LabNet gateway interfaces a client's computer or local network to the backbone. Software developed by the LabNet Project for the gateway and for the client's computers provides these value-added services:

1. Connection of like local networks in different buildings.
   Ethernet-to-Ethernet — available now

2. Connection of computers on different local networks that use the same higher level communication protocols.

Ethernet-to-Hyperchannel using LINCS	available now
Ethernet-to-Ethernet using DECNET	available now
Ethernet-to-Ethernet using TCP/IP	October, 1985

3. File transfer and terminal access to the supercomputers in the Livermore Computer Center with

PC-DOS computers over Ethernet	May, 1985
UNIX computers over Ethernet	July 1985
VMS computers over Ethernet	August, 1985

The first version of the gateway has been used to develop the value-added functions and has not been optimized for speed. A throughput rate of one million bits per second is the goal for the second version of the gateway. The high-speed network will eventually be fast enough that it is not a bottleneck for communication between computers.

A client's cost for a gateway to the LabNet high-speed network is currently $15,000. The cost for common-carrier service varies since each application is unique. In either case, the client must provide the cabling within the building to get from the backbone to the client's system. Underground cable that brings the backbone to the building entrance is in place or planned for the buildings shown in Appendix C. Any buildings not on the list can typically be added to the backbone with short runs of cable from a nearby manhole; this would be furnished by the client as well. The installation and maintenance of the LabNet connections will be charged to the client's account number.

The development of LabNet is expected to last through the end of FY 1988 and will cost approximately $9,000,000 of which $5,000,000 is for equipment and the rest for labor. Most of the equipment expenditures will occur in FY 1986 through FY 1988 to cover backbone cable installation and the purchase of gateways. An average of 8 FTEs will be required going from 6.5 now, to 10 in FY 1986, and then tapering off.

Major milestones for the project are:

1.	Beta test client on Open LabNet (EE VMS VAX network in 131 to Computation VMS VAX in 117)	July, 1985
2.	Beta test client on Closed LabNet (Sun workstation network in 381 to LCC)	August, 1985
3.	LabNet ready for service requests (up to PARD level)	October, 1985
4.	Second version of gateway ready for service	March, 1986
5.	Open LabNet cable installation complete	October, 1986
6.	Optical fiber cable installation complete	September, 1988

The rest of this document gives more details for the project and is divided into 7 sections and 3 appendices. Section 1 covers the motivation for

LabNet and the history of the project. Second 2 describes in detail what LabNet consists of and how it will operate. Section 3 shows the organization of the project and tells how it will be managed. The functional requirements for LabNet are listed in Section 4. Sections 5 and 6 show the breakdown of the project into tasks and the schedule for completion of these tasks. Details of the cost of the project are given in Section 7. Appendix A discusses possible solutions for terminal switching. Appendix B is an introduction to data communications protocols. Appendix C shows the list of buildings scheduled to be attached to LabNet.

1.0 Introduction

1.1 Definition

The Laboratory-wide Computer Network (LabNet) is an institutional communications utility specializing in high-speed computer-to-computer data transfers. Its main purpose is to provide an organized, efficient, and cost-effective means of connecting computers and local networks of computers, together between buildings. The switching of low-speed, unintelligent terminals to different computers will also be supported. Data communications within a building is the responsibility of the organizations residing there. LabNet project personnel can assist clients with their design for in-building communications.

LabNet supplies a multi-channel communications medium with at least one channel dedicated to serve as a Laboratory-wide high-speed packet-switching network. It is expected that most of the local networks attached to LabNet will be on this channel to achieve the most general interconnection of computers. Other channels are available to the programs to be used for unique dedicated purposes. One channel could be used as a general low-speed terminal-to-computer switching system (like Administration Information Systems Group's AdminNet). Another could be used for dedicated links between word processors or other computers, or as a very high-speed trunk for interactive graphics output from the LCC supercomputers.

There are two separate multi-channel systems that make up LabNet. One, called the Closed LabNet, can carry classified data since it uses cable installed in classified ducts and has terminations only in limited areas. The other, called the Open LabNet, uses cable installed in unclassified ducts and can terminate anywhere, but no classified data can be transferred across it. There is no data communications path between the Open and Closed LabNets due to the security requirements of the Closed LabNet. A device cannot be attached to both LabNets.

The Closed LabNet allows people to transfer classified data without going through the LCC. It also provides high-speed access to the LCC resources since the Octopus system of the LCC is one of the local networks attached to the Closed LabNet packet switch channel. It is expected that, rather than have their terminals directly wired to the LCC, many Octopus users will connect their terminals to a local network within their building and through it, access the LCC over the Closed LabNet.

The Open LabNet gives people a high-speed communications utility for transferring unclassified data that was not generally available before. The most common medium previously used, since it was already in the ground, was twisted pair leased from the telephone company. But these leased lines have limited bandwidth. Open LabNet offers much higher speeds and a packet-switched service.

1.2 Motivation

In the early days of computing at the Laboratory, computers were very expensive and required a great deal of care and feeding. This high cost of ownership limited the number of computers on site and encouraged their location in a single building, the Livermore Computer Center (LCC). To provide access to these computers, terminals (basically slow communicating typewriters) were placed in all the buildings where users required them. A television monitor display system (TMDS) which displayed on each monitor 512 lines of 512 dots for text and graphics was added later. Each terminal was wired directly to the LCC using inexpensive twisted pair; each TV monitor was also wired directly to the LCC with coaxial cable. All of the computing needs of the Laboratory were met with this computer communications system.

Today, this centralized system of terminals and monitors tied to the LCC still exists, but the terminals have evolved to video display terminals and personal computers (PCs) that can transmit data at much higher rates. The PCs are performing some of the computation and storage tasks previously done by the computers in the LCC as well as acting like terminals. In addition, there are many minicomputers, word processors, and scientific workstations in locations outside the LCC. The workstations are capable of higher resolution graphics than TMDS and can also display different colors.

To make effective use of these distributed computer resources, the Laboratory needs an efficient means to transfer data between the computers. It cannot be assumed that all of a person's computing needs can be met by a machine in his building or by the LCC. The fact is that computer systems are specialized for certain functions such as supercomputer number crunching, engineering tools, or a purchase order database. Not only may a person need interactive access to several computer systems, but those he uses may need to communicate with yet other machines to get at required data. High-speed communications is needed to minimize the delay in interaction and the time to transfer large files of data. The LabNet Project provides a high-speed data communications utility for all of the computers at the Laboratory. A variety of services are offered, to which a client subscribes as needed. Clients retain autonomous control of the systems attached to LabNet.

The general trend of data communications at the Laboratory is toward local networks within buildings, or a group of buildings, that serve the needs of a program or support group. It is expected that most terminal interaction and intercomputer communication requirements can be met by these networks. Each group installs the type of network that best meets its needs, whether it be Ethernet, or a broadband network, or a data switch. But, sometimes the group to be served by a local network is spread widely among several buildings. The local network may even span the Laboratory like AdminNet. And, although most of the required computer resources exist on the local network, there is some need to communicate with other networks in other buildings for document transfer, database access, supercomputer number crunching, or electronic mail.

The traditional method of providing communications between buildings has been to use existing twisted pair in the telephone or classified ducts at relatively slow speeds using point-to-point connections, or to pull new cables of the special type that were required. Each program acquired duct space as it was required with no coordination with other programs. The result is that we now have a clogged and poorly mapped underground duct and cabling system. Any new plans for communications between buildings are expensive to implement because of the manpower required to design a route through the existing maze, pull new cable, and/or install new ducting. LabNet provides a Laboratory-wide cable system underground between buildings that eliminates most of the need for programs to install their own cables. This is another aspect of LabNet as a utility. Like the telephone company, LabNet provides "wires" between buildings for clients to use as they wish.

1.3 History

In 1981, the LabNet idea was first put forward as a way of connecting remote computers to the LCC at high data rates. High bandwidth cables were already in the ground: the coaxial cable used for the LCC's Television Monitor Display System (TMDS). Hardware was commercially available to make a high speed broadband network using that cable. The Computation Department started an experiment to determine the feasibility of using a TMDS cable broadband network to transfer data from a Sun workstation to a Cray supercomputer in the LCC on a packet-switched channel.

Figure 1 is a block diagram of this experiment. Hardware from Ungermann-Bass (U-B) was chosen to provide a packet-switched channel on the broadband network because it offered interfaces with the highest data rates. A gateway computer between the Sun or Cray end computers and the U-B hardware was deemed necessary to minimize changes to the software in the end computers. The gateway would also be programmed to enforce security levels. Octoport was chosen as the gateway to the Cray. Octoport is connected to the Cray by a Hyperchannel local network; it is designed for packet switching. A Motorola 68000 and Multibus based computer from CYB Systems running the Unix operating system was picked as the developmental gateway to the Sun. It was connected to the Sun with an Ethernet. The 68000, the Multibus, and the Unix operating system are all industry standards, and the CYB was chosen as a low-cost unit incorporating all of them. It was felt that the use of these standards would make it easy to interface to almost any local network that would be attached to LabNet. The CYB also came with networking software that reduced the coding effort required for the experiment.

In 1984, the gateway software was sufficiently developed to move packets between the Sun and a Cray, and the experiment was declared a success. The Computation Department was given the charter to produce a full scale LabNet. Because of the existing TMDS cable in the ground, a coaxial cable-based broadband network was picked as the most cost-effective medium for the Closed LabNet.

The Open LabNet had other media options since there was no existing high bandwidth cable underground. (There is the Instructional Television broadband coaxial cable system, but nearly all of the channels are already in use.) Through-the-air laser links between buildings cost at least twice as much as a coaxial cable network and suffer from environment-related reliability problems. Optical fiber cable is attractive since it offers very high bandwidth. However, there is

LabNet experiment

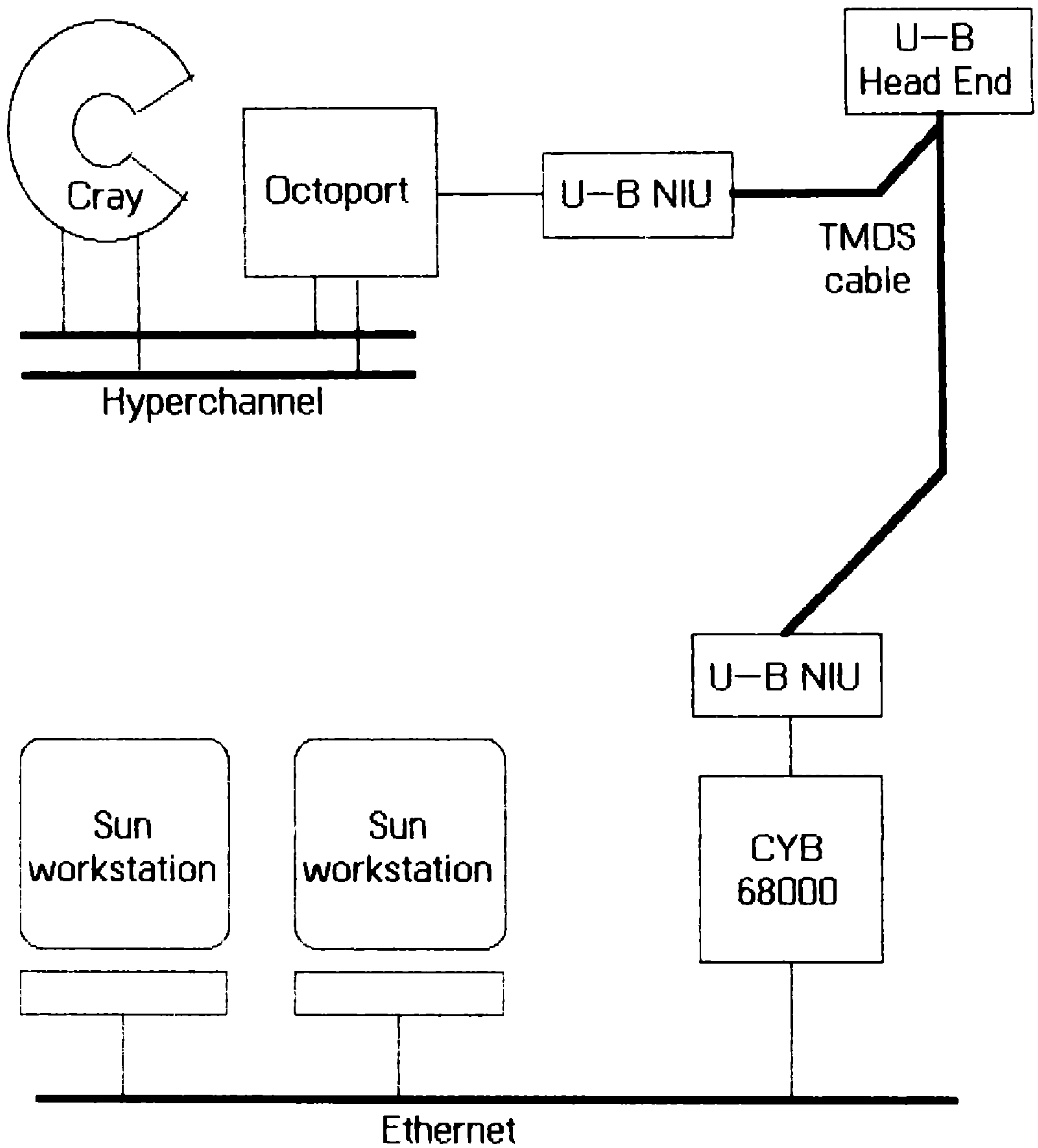


Figure 1

currently no packet-switched networking system operating with fibers that offers any bandwidth advantage over coaxial cable. Also, fiber sizes are not standardized and fiber cable will cost more than coaxial cable for a few more years. A broadband coaxial cable network for Open LabNet also ensures a commonality of parts and technology with the Closed LabNet. The deciding factor for coaxial cable was the planned installation of a broadband local network for AdminNet in 1984. It was decided to make Open LabNet cable part of that installation.

2.0 Description

2.1 Hardware

The LabNet consists of a backbone cable system and gateway machines for the packet-switched channel (see Figure 2). The main tasks are installing the cable system between buildings and programming the gateways with proper protocols. A terminal switching system that can connect any terminal to any computer on LabNet is not a main part of this plan. LabNet could be used as the communications medium for such a system, however. Some possible approaches to a terminal switch are discussed in Appendix A.

2.1.1 Backbone Cable System

The initial medium for LabNet is broadband coaxial cable installed as a branching tree using standard CATV components. This medium provides 20 to 30 pairs of 6 MHz channels of communications. One pair of channels is used for the high-speed LabNet packet-switch channel. Modems are commercially available that will transmit up to 10 Mbps on one 6 MHz channel. Even higher data rates are possible if more than one channel is used.

The Closed LabNet will use existing TMDS cable. No new underground coaxial cable is necessary since TMDS cables already go to every building in the limited areas.

For the Open LabNet, new coaxial cable is being installed to most of the major buildings. The installation will require two years, at least, and the choice of buildings is based on requests from potential users. In FY84, cable was pulled to several buildings at the same time that another cable for AdminNet, the terminal-switching local network for Administration Information Systems Group, was installed. Currently, AdminNet uses one coaxial cable while Open LabNet uses the other. However, they are both broadband systems and can coexist on the same cable, so two cables provides sufficient redundancy for both networks. In FY85 and FY86, the two coaxial cable system will be extended to additional buildings (see Appendix C).

In a few years, the LabNet cable system will be augmented with an optical fiber network that will offer much higher channel bandwidth. It is expected that by 1987 a preferred size of optical fiber will be established, and that local network products that take full advantage of optical fiber properties will be available. (One company recently announced an 80 Mbps optical fiber network.) In preparation for the installation of optical fibers, everywhere that coaxial cable is being pulled for Open LabNet, a subduct for the fiber cable is also being pulled to reserve space underground. Subduct for the Closed LabNet will be retrofitted to the classified duct system starting in FY86. It is likely that the distribution system for the Laboratory's new voice PBX will include optical fiber cable. Installation of fiber for LabNet and the PBX will be coordinated to minimize costs and the need to dig trenches for new cable ducts.

LabNet

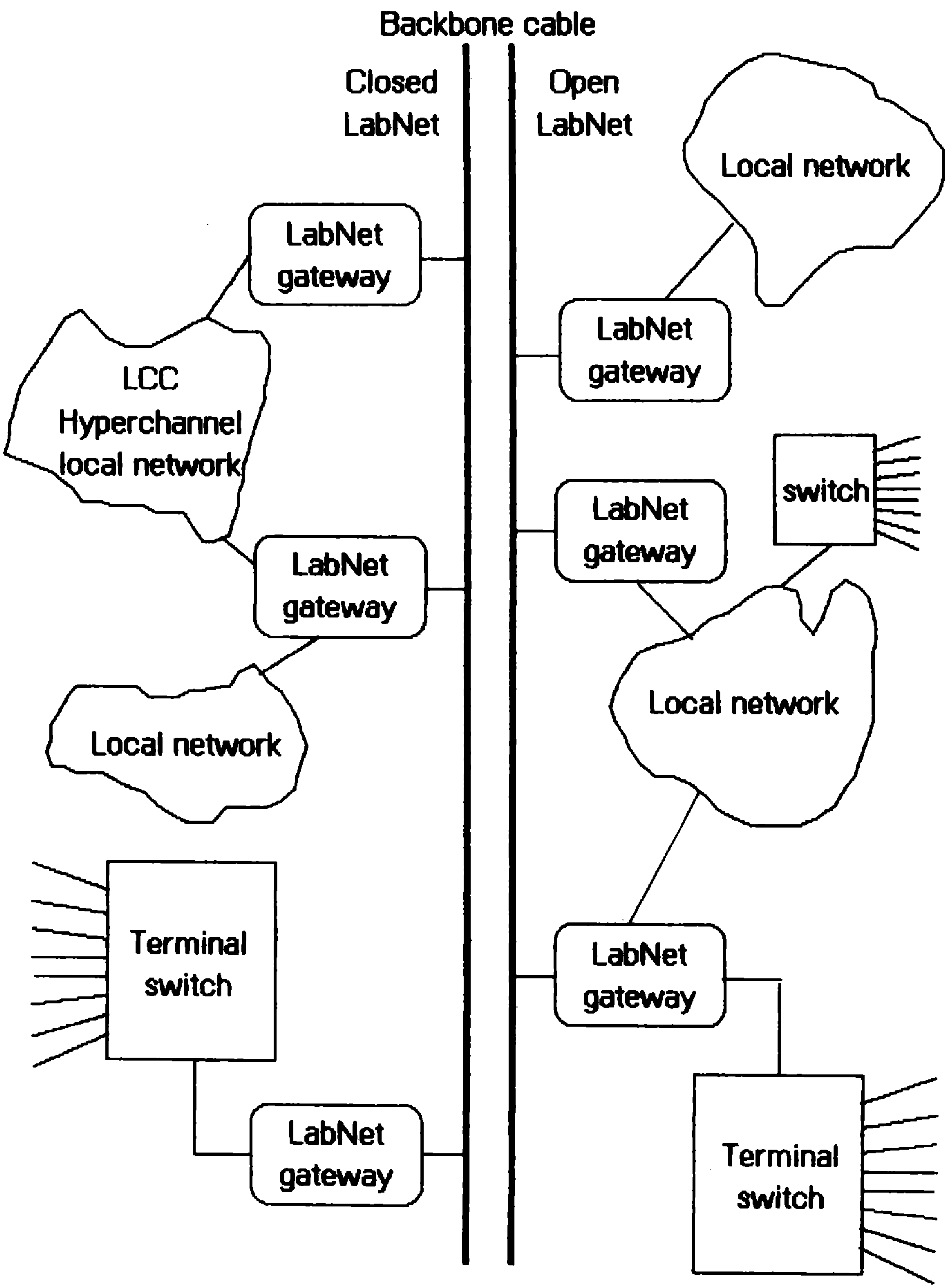


Figure 2

2.1.2 Gateway

The LabNet gateway is the connection between a building's local network and the packet-switched channel of LabNet. This connection currently consists of two units: a broadband network interface and a gateway computer. The broadband network interface is the Net-One NIU from Ungermann-Bass which provides a 5 Mbps data rate in the 6 MHz channel. The NIU offers a simple packet switch service called datagrams that is most appropriate for network-to-network communications. The gateway computer is a Multibus-based system running the UNIX operating system.

A major task for LabNet is to replace the current two-unit development gateway with a single production unit to reduce the cost and to increase the throughput. The new gateway will run software dedicated to the task of moving packets between the local network and LabNet. It will be a small unit that can be locked up in a wiring closet and operated remotely. It will be usable on baseband or broadband coaxial cable systems, or with optical fibers. The throughput goal for the new gateway is one millions bits per second.

2.1.3 Special Needs

Since the LabNet medium offers multiple channels but the LabNet packet-switched service only uses one pair of them, other channels are available for private use by Laboratory programs. Broadband modems are available commercially for point-to-point links at data rates from 9600 bps to 1.5 Mbps. These other channels can also be used for private networks. The AIS AdminNet is an example of such a network; it offers terminal access to AIS computers. On the Open LabNet, a group of channels will be used to create a broadband Ethernet using DEC's DECOM transceivers. This will be used by the EE Department for their CAE network of VAXs.

The measured data throughput on the LabNet packet channel does not yet meet the needs of clients who require high resolution interactive graphics from the LCC supercomputers. This group includes nuclear designers and engineers working with CAD/CAM systems. It is expected that the later versions of the packet channel will provide enough throughput. In the meantime, a task of the LabNet project is to investigate how to provide high bandwidth connections from the supercomputers to these users in the near term. These connections may be special direct links between the LCC and the users over dedicated channels of the LabNet cable system. An experiment that uses an Ethernet to directly connect Octoport to a graphics terminal in Building 111 is in progress. The goal is to achieve at least 1 million bits per second for data transfer from a Cray to the terminal.

2.2 Software

The major programming effort for LabNet is to have the gateway pass packets between the LabNet packet channel and the local network. Other tasks are to provide communications packages for the client's computers and network management software.

2.2.1 Gateway

To move packets between LabNet and the local network, the gateway computer must implement communication protocols and privacy controls. Protocol implementation involves the packaging and routing of packets. Privacy controls restrict the movement of packets between LabNet and the local network.

With respect to the OSI reference model for communication (see Appendix B), LabNet acts as a relay system between local networks. To provide the service of connecting local networks, the data link and network layers are the ones of most concern in the LabNet gateway. Two tasks have been defined for the LabNet gateway. One is to act as a selective repeater at the data link layer, and the other is to act as a network layer gateway.

Local networks that use the same data link layer protocol can communicate over LabNet with the selective repeater (Figure 3). The selective repeater looks at all data link layer packets on the local network. Those that are destined for a different local network are transported over LabNet to that local network and the full data link layer packet is reproduced on that network. In this case, the LabNet gateway is invisible to the hosts on the local networks and is insensitive to the higher layer protocols. The first implementation of the selective repeater connects together two Ethernet local networks. It has been tested on the Open LabNet with VAX computers communicating with DECNET. Since the higher layer protocols are invisible to the selective repeaters, computers running TCP/IP could be on these two Ethernets as well, and communicate. Of course, the selective repeater cannot help an application on a DECNET computer to communicate with one using TCP/IP.

Computers on local networks that use different data link layer protocols but agree on the network layer can exchange packets using the network layer gateway (Figure 4). This gateway receives data link layer packets directed to it on the local network and extracts the network layer packet. The destination is determined from the extracted packet, and the packet is transported over LabNet to the local network containing the destination. The network-layer packet is then packaged in a data link layer packet appropriate to the destination local network. In this case, the LabNet gateway is known to the hosts on the local network, and packets destined for hosts not on the local network are explicitly routed to the LabNet gateway. Protocols above the network layer are not of concern to the gateway, but the end computers must agree on them in order for the applications to communicate. The first implementation of the network layer gateway connects together Sun workstations on an Ethernet local network with the Cray supercomputers on the Hyperchannel in the LCC using the LINCS protocol.

Neither the selective repeater nor the network gateway solves the general problem of allowing applications on two computers using different protocols to talk to each other. This problem is best solved by translation software that involves all seven protocol

Selective repeater

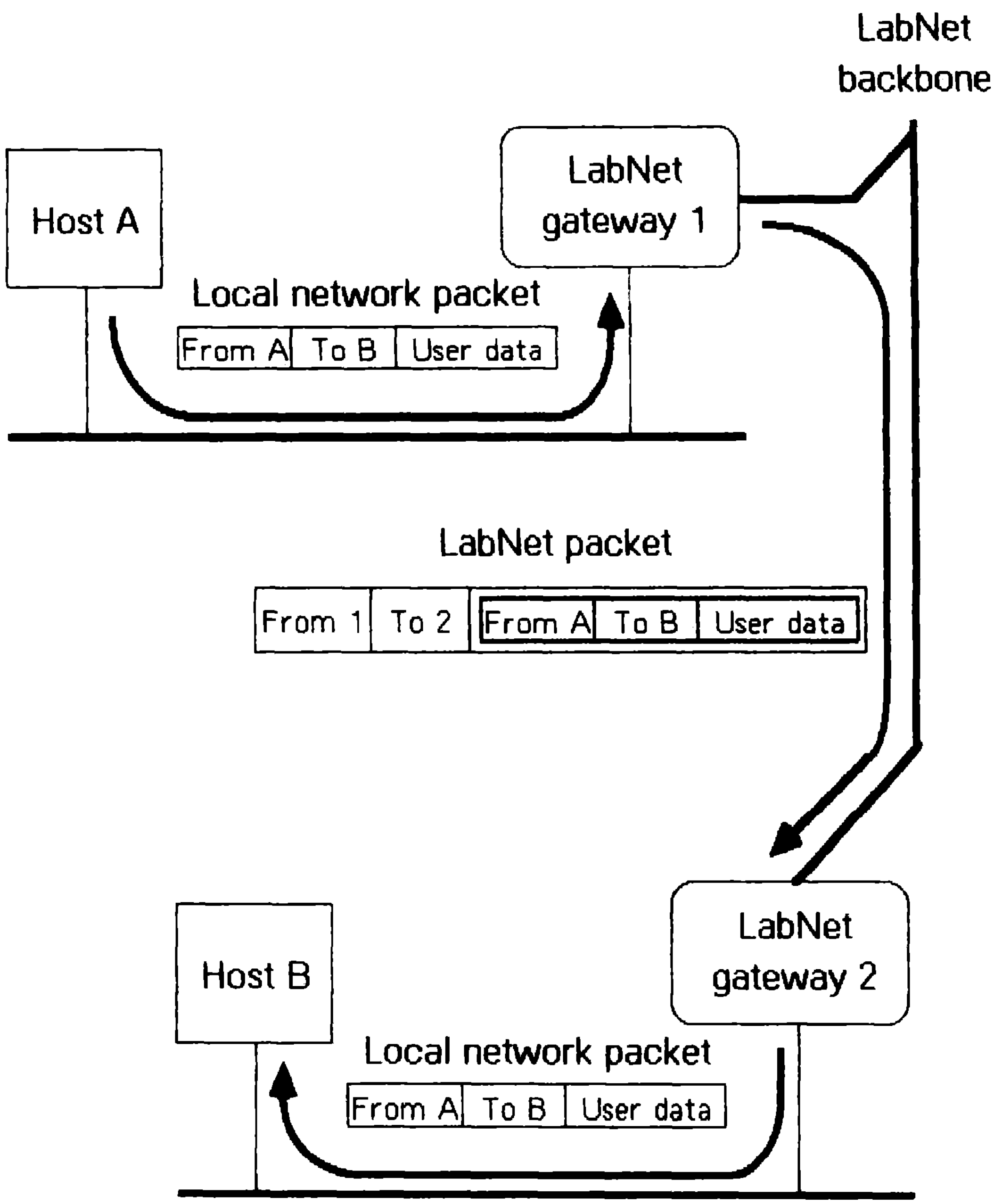


Figure 3

Network layer gateway

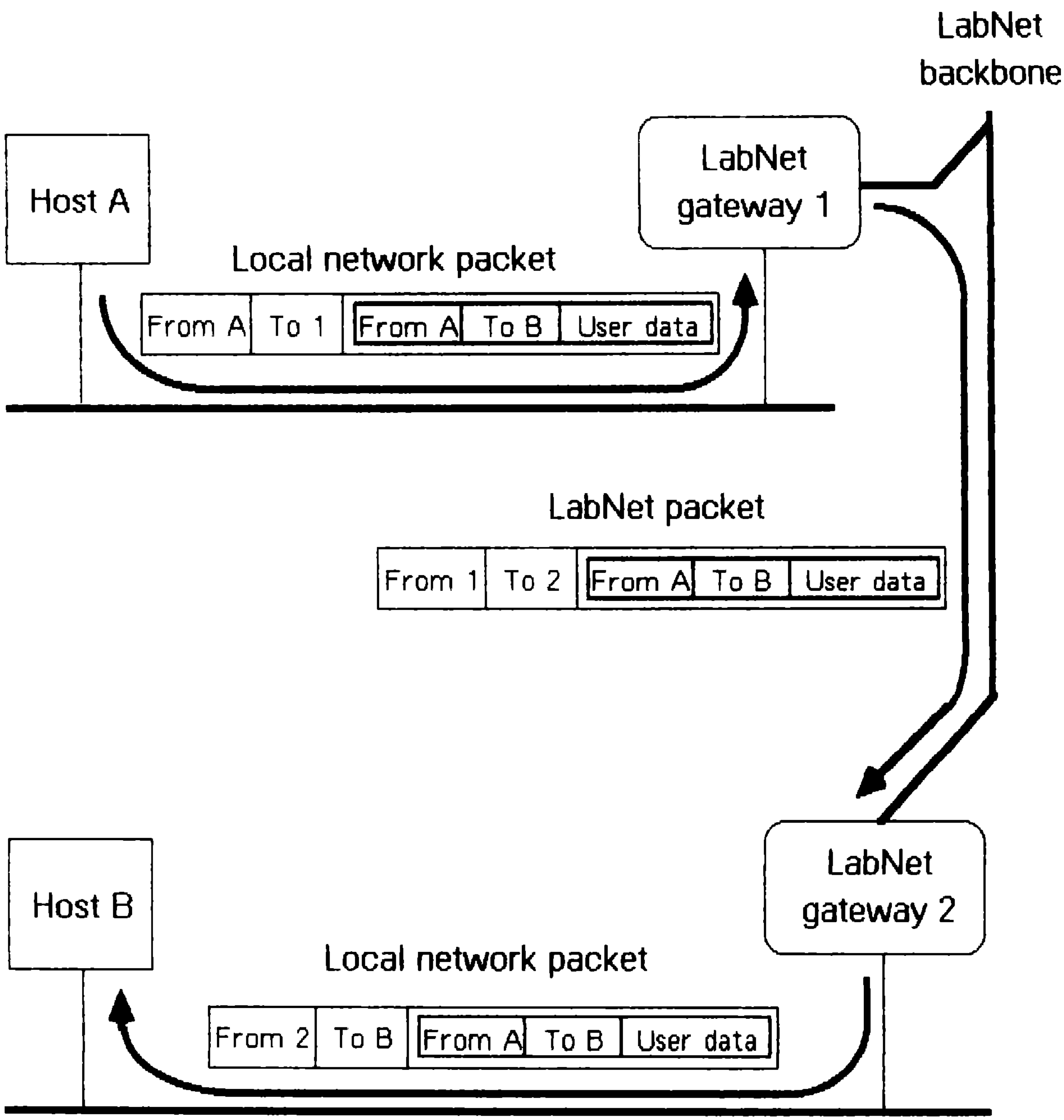


Figure 4

layers in one or both of those computers, or perhaps in a third computer dedicated to the translation task. The LabNet gateway is tailored for efficient delivery of packets, not translation. The project will investigate the possibility of providing a translation computer as a service on LabNet. International standardization efforts should ease this task. LabNet will support standard protocols as they become available. At the data link layer, local networks using IEEE 802 standards will be supported. A network layer protocol is expected soon from ISO and will be used within LabNet for routing packets on the backbone between gateways.

Privacy controls are implemented based on source and destination addresses as well as security level information. While no firm requirements for address-based controls have been established, the project will investigate options for restricting the flow of packets into a local network to those that are from specific sources or those destined for particular nodes. Similarly, flow out of the local network could be restricted to packets originating from certain nodes or intended for specific destinations. Address-based restrictions can be used to limit traffic on the local networks as well as to control privacy.

Restrictions based on security levels are optional in the Open LabNet and mandatory in the Closed LabNet. Each local network has an assigned security level that applies to all nodes on the network. Only packets marked with that security level, or a lower level, can pass between the local network and LabNet. In the case of the selective repeater, no security level information is available in the link layer packets being examined, so the assumption is that all local networks communicating in this way are at the same level. The network gateway examines the security level information in the network level packet to exercise the controls.

2.2.2 Client Systems

A goal of the LabNet project is to be transparent to clients so that no software changes are necessary in commercially acquired systems. Wherever possible, the LabNet gateways will accommodate the protocols used in these systems. An exception is made in the case of communication with the LCC since the LINCS protocol is the only way to communicate with the supercomputers but is not available commercially. Software for clients' systems that implements the LINCS protocol is a task for LabNet. Application code to perform file transfers and terminal emulation using LINCS is part of the task. Work is in progress on implementations for VAX computers running VMS or UNIX 4.2 BSD, IBM PCs, and for Sun workstations running UNIX 4.2 BSD. Much of the code is portable to other machines.

2.2.3 Diagnostics

Software that allows effective management of the backbone network is the third major programming effort. It is expected that the vendor of the hardware for the gateway will supply monitoring and control packages that can be used as the basis for the LabNet management task. These packages provide configuration control for the addition or removal of gateways, remote initialization of gateways, and basic statistics on the number of packets transmitted and the number of errors detected. The project will build upon this to automate testing of hardware, analysis of performance, and notification of failures or congestion.

2.3 Administration

This section briefly describes the procedures for operating the LabNet when its services are generally available.

2.3.1 Client Orders

A LabNet Coordinator will be identified as the point of contact for a prospective client of LabNet. The Coordinator will obtain from the client a description of the equipment to be connected, its location, and the desired date of connection. The Coordinator will inform the client of connection and usage costs, necessary preparations the client must make, and the expected date of connection. The Coordinator then works with the client and the LabNet installation team to make the connection.

In general, orders are filled on a first come, first served basis if cable exists underground to the desired building. If new cable must be installed, the connection is necessarily delayed. An informal survey of potential LabNet clients was made in 1984 to identify buildings that are likely to be connected to the Open and Closed LabNets. Based on this survey, plans were made to have cable in the ground to these buildings by the end of FY 1986. (See Appendix C.) Any other buildings can typically be attached to the backbone with a drop cable from a nearby manhole.

The first client, outside of the Computation Department, will be the EE Department in Building 131 which has volunteered to test the selective repeater function between VAX computers on the Open LabNet. The LASNEX programmers in Building 381 have agreed to test the network gateway on the Closed LabNet between their Sun Workstations and the LCC. Other clients will be added when all the LabNet software and hardware has been tested.

The cost to the client and the mechanism of payment for a LabNet connection will be specified before LabNet goes into production operation. The cost for connecting to the packet channel includes the gateway hardware, any in-building cabling, and perhaps a drop cable to the backbone. The Computation Department is buying a few gateways as seed units. These will be used to fill client orders quickly; the client will pay for a replacement. Installation and maintenance of LabNet connections will be charged to the client's account number. A periodic charge for usage of LabNet may be made to pay for the maintenance of the shared portion of the network.

2.3.2 Installation and Maintenance

A small team consisting of the LabNet Coordinator and at least one programmer, one hardware technician, and one physical plant representative will install and maintain the LabNet hardware and cable system. The team acts on requests by the LabNet Coordinator for new installations. They will work with the client's technical people and building coordinator to plan the installation. The team monitors the daily operation of LabNet for signs of malfunction or service degradation and schedules preventive maintenance. They call upon the services of the Electronics Engineering Department for maintenance of the electronics, and Plant Engineering Department for cable installations. Software modifications are handled by the Computation Department.

This team will be in charge of allocation of channels on the broadband system. They will also act as advisors to users who are considering any type of interbuilding data communications.

2.3.3 Security

The security of the LabNet packet channel is enforced through physical and electronic procedures. All gateways will be in locked enclosures to restrict physical access. The gateway software checks the security level of all packets going through the gateway as described in Section 2.2.1. Only the LabNet programmers can modify the gateway software. Gateways can be remotely disabled to isolate them from the network.

To preserve the security of the cable system, the procurement, installation, and maintenance of all cable and hardware will be controlled by the LabNet installation team. Mechanisms for the monitoring of the cable system to detect intrusion will be investigated. A security plan for the project will be written before LabNet goes into production use. Until the security plan is approved, the maximum security level of data on the Closed LabNet is limited to PARD.

3.0 Project Organization and Management

3.1 Organization

LabNet is a project of the Computation Department (Figure 5) with oversight by the Information Technology Steering Committee (ITSC). Four FTEs are designated for LabNet under the Department's New Initiatives Program. One FTE is the LabNet Project Manager, and the other three are gateway programmers. The Project Manager reports directly to the Department Head.

The Project Manager directs the development, installation and operation of the hardware and software for LabNet. The gateway programmers design and produce the software in the LabNet gateway for delivering packets and for managing the network. Other tasks are performed by people in various departments through the normal matrix structure.

3.2 Management of Changes

This plan (especially section 4.0, which lists the functional requirements) is the foundation document for the LabNet project. It describes what is to be accomplished and when it will be done. Its first publication will be reviewed in stages by the LabNet project team and by the Computation Department Head and Technical Staff (DTS) and the Associate Director for Computations, and then released for comment to the ITSC and prospective clients. It is the Project Manager's responsibility to keep this plan updated to reflect changes in requirements, implementation, and schedule.

Once this plan is accepted by the ITSC and the user community, changes to the plan will be made only after a reasonable period of publicity and discussion. The Project Manager will maintain a mailing list of people interested in LabNet. All written material will be istributed to this mailing list as well as to Computation Department and other publications including the Tentacle, Octopus Communique, and Octogram, as appropriate.

The LabNet project team will meet at least once a month to discuss progress, report problems, and suggest changes to the plan. Anyone who wishes to make comments or suggestions should contact the Project Manager or any of the team members so their views can be heard at the meeting. The meeting will result in a progress report that will be widely disseminated.

Twice a year, the project team will hold a meeting open to the general Laboratory population to describe the state of LabNet and to solicit comments. These meetings will be regularly held only during the development phase of the project. Once LabNet reaches a routine production stage, a general meeting will probably not be necessary unless a significant change in operation is proposed.

Throughout the life of this plan, changes in the requirements or tasks will be made through a semi-formal process of discussion and

LabNet Project Organization

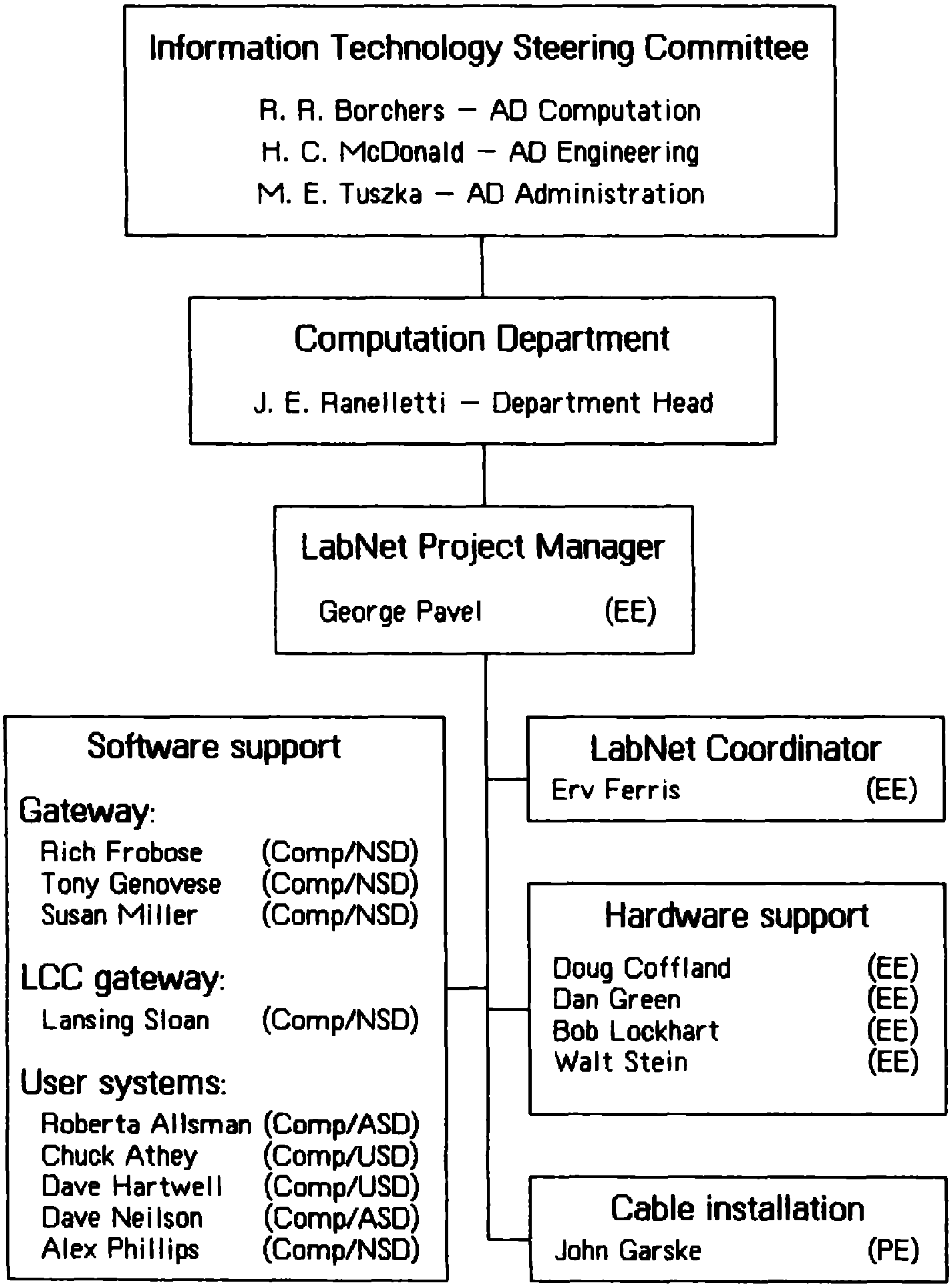


Figure 5

approval. The first level of approval is by a majority decision of the project team. The proposed changes are then discussed and approved by a committee which includes the LabNet Project Manager and representatives of LabNet clients who would be affected. The changes are then written down as a draft revision to the plan and presented to the ITSC, DTS, and the interested community for comments. The draft revision will specify the period for accepting comments. If no unresolvable objections are received within that time, a new revision of the plan, incorporating the changes will be issued.

3.3 Management of Work and Documentation

Sections 5.0 and 6.0 describe the tasks to be performed and the schedule to be followed for these tasks. The schedule charts will be updated as work is performed or changes are made. Updated charts will be included in the monthly progress report.

All software for the LabNet gateways will be developed using structured design techniques starting with the work on the second generation gateway. The resulting analysis and design documents, together with the source code and any explanatory notes, will constitute the full documentation for the software. All code, where possible, will be written in the high-level language, C.

Documentation for hardware and cabling will include operation and maintenance manuals for all electronics, cabling diagrams, a list of channel allocations, and a list of attached networks and hosts and their protocols and addresses. When a monitoring facility is available, the monthly progress reports will include statistics on LabNet usage and maintenance calls.

4.0 Functional Requirements

4.1 Characteristics

4.1.1 General

4.1.1.1 LabNet shall provide a data communications medium between buildings so that individual programs will not have to install their own.

4.1.1.2 LabNet shall provide data communications channels that can accommodate a variety of data rates.

4.1.1.3 LabNet shall provide data communications channels that are suitable for transporting classified data (Closed LabNet).

4.1.1.4 LabNet shall provide data communications channels for systems that are connected to public networks (Open LabNet).

4.1.1.5 The hardware boundary between LabNet and the local network shall be clearly defined. All hardware and software on the LabNet side of the boundary shall be the responsibility and under the control of the LabNet project. All hardware and software on the local network side shall be the responsibility and under the control of the local network administrator.

4.1.1.6 LabNet shall be designed to adhere to hardware and software standards wherever possible. This specifically includes communications protocol standards.

4.1.1.7 All LabNet software shall be written in a high-level programming language. All such software shall be designed using structured techniques.

4.1.1.8 Changes to the software or operation of local networks, or nodes attached to them, for the purpose of attaching to the LabNet packet channel shall be minimized. It is preferred that no changes be required.

4.1.2 Packet Channel

4.1.2.1 LabNet shall provide at least one data communication channel for the general interconnection of computers (the packet channel). This channel shall provide high data rates suitable for moving large volumes of data.

4.1.2.2 The LabNet packet channel shall interface to local network types that are commonly used within buildings at the Laboratory. Ethernet is one of these local network types.

4.1.2.3 The LabNet packet channel shall transport data packets for all communications protocols that are commonly used within the Laboratory. LINCS, DECNET, and TCP/IP are three of those protocols. Translation between protocols is a desired feature. National and international standard protocols shall be supported when they are available in commercial products.

4.1.2.4 The Closed LabNet packet channel shall provide access to the Octopus system in the Livermore Computer Center. Access shall be through the use of the LINCS protocol.

4.1.2.5 The LabNet packet channel shall provide facilities to restrict the flow of data between LabNet and the local network for security, privacy and traffic control reasons.

4.1.3 Operation

4.1.3.1 LabNet shall operate unattended. Any part of LabNet shall automatically restart after the part suffers a power failure.

4.1.3.2 LabNet hardware which connects local networks to the packet channel shall be able to be shut down or reinitialized remotely over LabNet upon demand from an authorized node. Mechanical data storage units shall not be required as part of this hardware, although they may be used as an alternate for reinitialization.

4.1.3.3 LabNet shall report the status of all of its parts periodically to a maintenance center or upon demand to an authorized node attached to LabNet.

4.1.3.4 LabNet shall provide statistics on packet channel performance. These statistics shall be reported periodically to a maintenance center or upon demand to any authorized node attached to the packet channel.

4.1.3.5 LabNet packet channel hardware shall be able to run diagnostics under remote control.

4.1.4 Media

4.1.4.1 The LabNet communications media shall make efficient use of and minimize the space required in the underground ducting system.

4.1.4.2 LabNet shall provide fully redundant communications media underground.

4.1.4.3 LabNet shall provide sufficient capacity in the communications media underground to cover Laboratory needs for at least ten years.

4.2 Performance

4.2.1 Throughput for file transfers with the LCC on the LabNet packet channel shall at least equal that obtained on the highest speed Octoport serial line. One million bits per second is the desired minimum.

4.2.2 LabNet shall not be a bottleneck for file transfers between local networks. If the packet channel has a faster signalling rate than the local networks, file transfer between local networks shall have the same throughput as transfers within the local networks. If the packet channel is slower, file transfers should not slow down more than can be accounted for by the difference in signalling rates.

4.2.3 Point-to-point connections on LabNet shall be capable of data rates exceeding one million bits per second. Ten million bits per second is desired. One hundred million bits per second is a five-year goal.

5.0 Project Tasks

5.1 Backbone

5.1.1 Install coaxial cable and fiber subduct to buildings for Open LabNet (See Appendix C).

5.1.2 Free up TMDS cable and install fiber subduct to buildings for Closed LabNet (See Appendix C).

5.1.3. Install optical fiber backbone

5.2 Gateway

5.2.1 CYB gateway

- 5.2.1.1 Develop selective repeater
- 5.2.1.2 Develop network gateway for LINCS packets
- 5.2.1.3 Develop network gateway for IP packets
- 5.2.1.4 Optimize gateway code

5.2.2 New gateway

- 5.2.2.1 Specify new gateway and development tools
- 5.2.2.2 Procure and install new gateway
- 5.2.2.3 Port CYB gateway functions to new gateway
- 5.2.2.4 Develop new gateway function
- 5.2.2.5 Replace old gateways
- 5.2.2.6 Develop gateway for fiber optic backbone

5.2.3 PBX

- 5.2.3.1 Develop gateway to PBX
- 5.2.3.2 Test gateway
- 5.2.3.3 Install gateway

5.3 Protocols for client systems

5.3.1 UNIX

- 5.3.1.1 Interface Sun workstations to LabNet over Ethernet
- 5.3.1.2 Interface VAXes to LabNet over Ethernet
- 5.3.1.3 Develop LINCS protocol layers

5.3.2 VMS

- 5.3.2.1 Interface VAXes to LabNet over Ethernet
- 5.3.2.2 Develop LINCS protocol layers

5.3.3 PC-DOS

- 5.3.3.1 Interface IBM-PC to LabNet over Ethernet
- 5.3.3.2 Develop LINCS protocol layers

5.3.4 Protocol standards (these tasks are not scheduled yet)

5.3.4.1 Replace LINCS network layer with ISO standard
5.3.4.2 Replace part of LINCS data link layer with IEEE 802.2

5.4 Special Needs

5.4.1 Megabit channel to Octopus

5.4.1.1 Evaluate alternatives for the design of the channel
5.4.1.2 Procure hardware
5.4.1.3 Install and test hardware
5.4.1.4 Code and test changes to Octoport software
5.4.1.5 Code and test user software
5.4.1.6 Develop drivers for channel hardware
5.4.1.7 Test the channel

5.4.2 Develop broadband Ethernet channel

5.5 Connections

5.5.1 Install Open LabNet connection between 131 and 117 VAXs.

5.5.2 Install Closed LabNet connection between Sun System in 381 and LCC in 113.

5.6 Administration

5.6.1 Prepare security plan
5.6.2 Wait for approval of security plan
5.6.3 Develop network monitor
5.6.4 Prepare client order procedure
5.6.5 Train installation team
5.6.6 Advertise LabNet availability
5.6.7 Present on-site local network training seminars

6.0 Project Schedule Charts

Start date	Finish date
Description of task	
Person(s) responsible	Number of days to complete task

Date

The main schedule chart for the project consists of four pages labeled A, B, C, D in the upper or lower right corner of each page. The pages are meant to be arranged in this way:

A	B
C	D

No people are shown on this chart because the limitations of the charting program prevent the realistic portrayal of multiple people on one task, and one person on multiple tasks during the same time period, without complicating the chart unnecessarily.

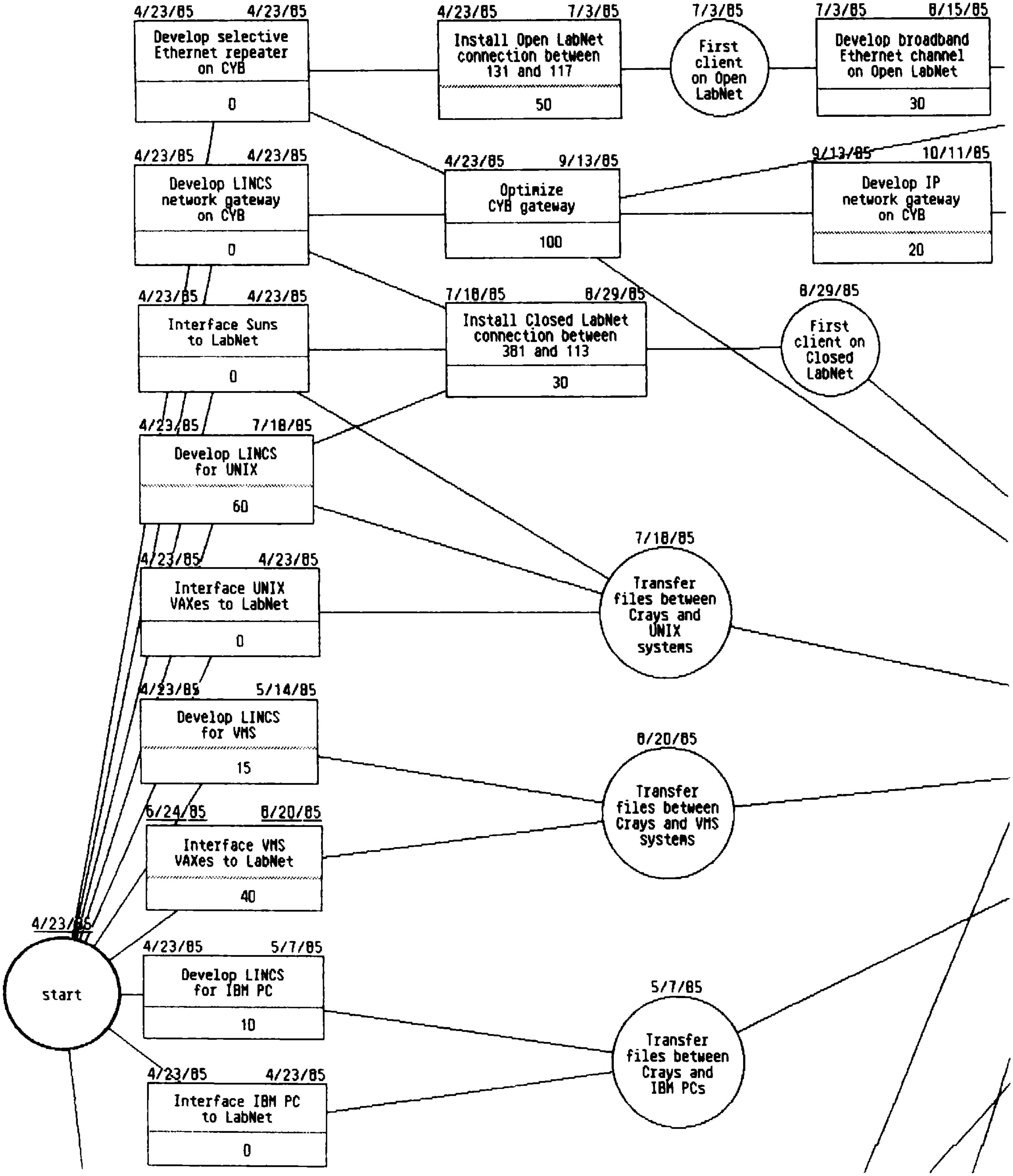
Attached as a separate chart is the schedule for the experiment to provide a one megabit-per-second channel from a Cray to a graphics workstation in Building 111.

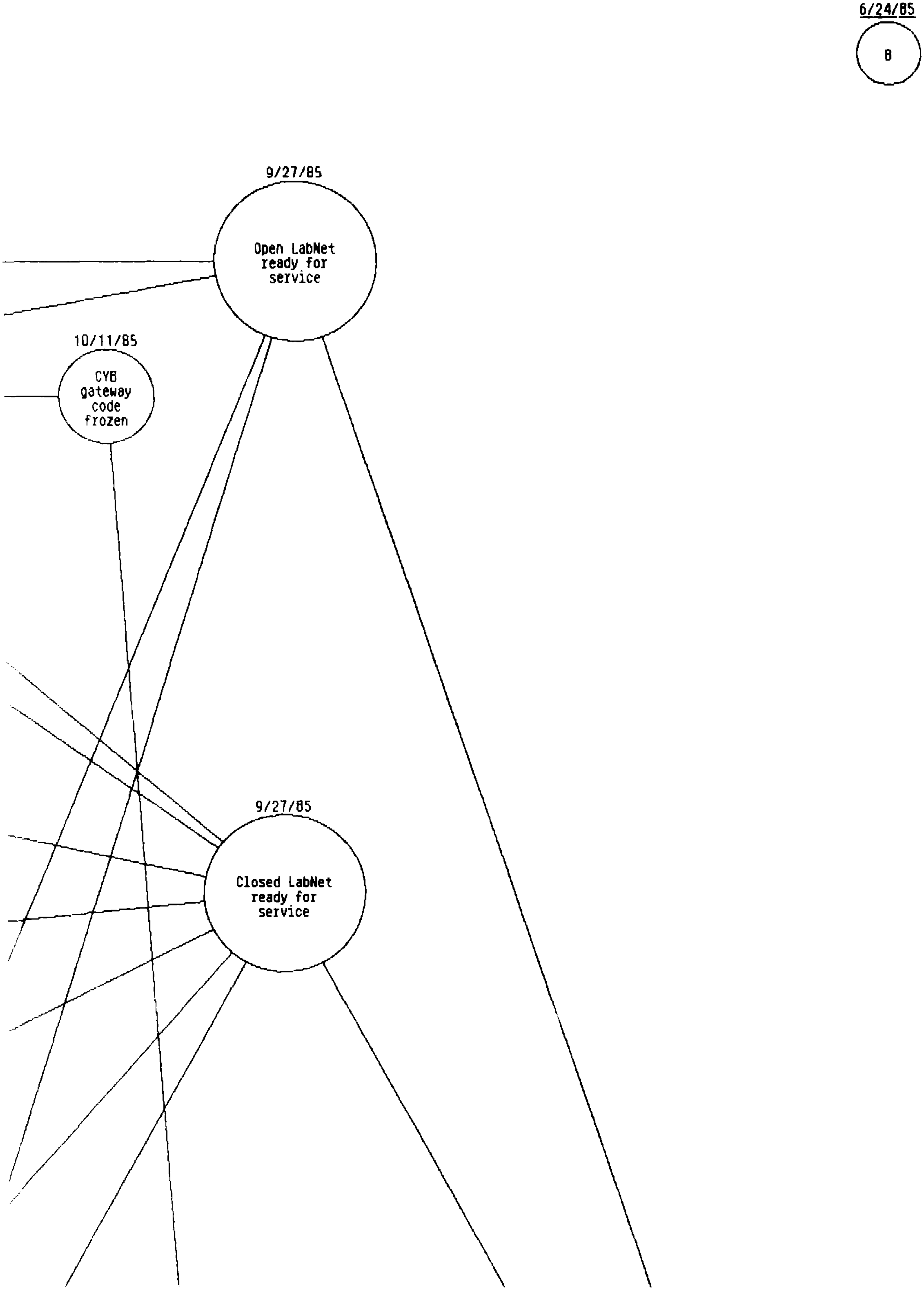
6/24/85

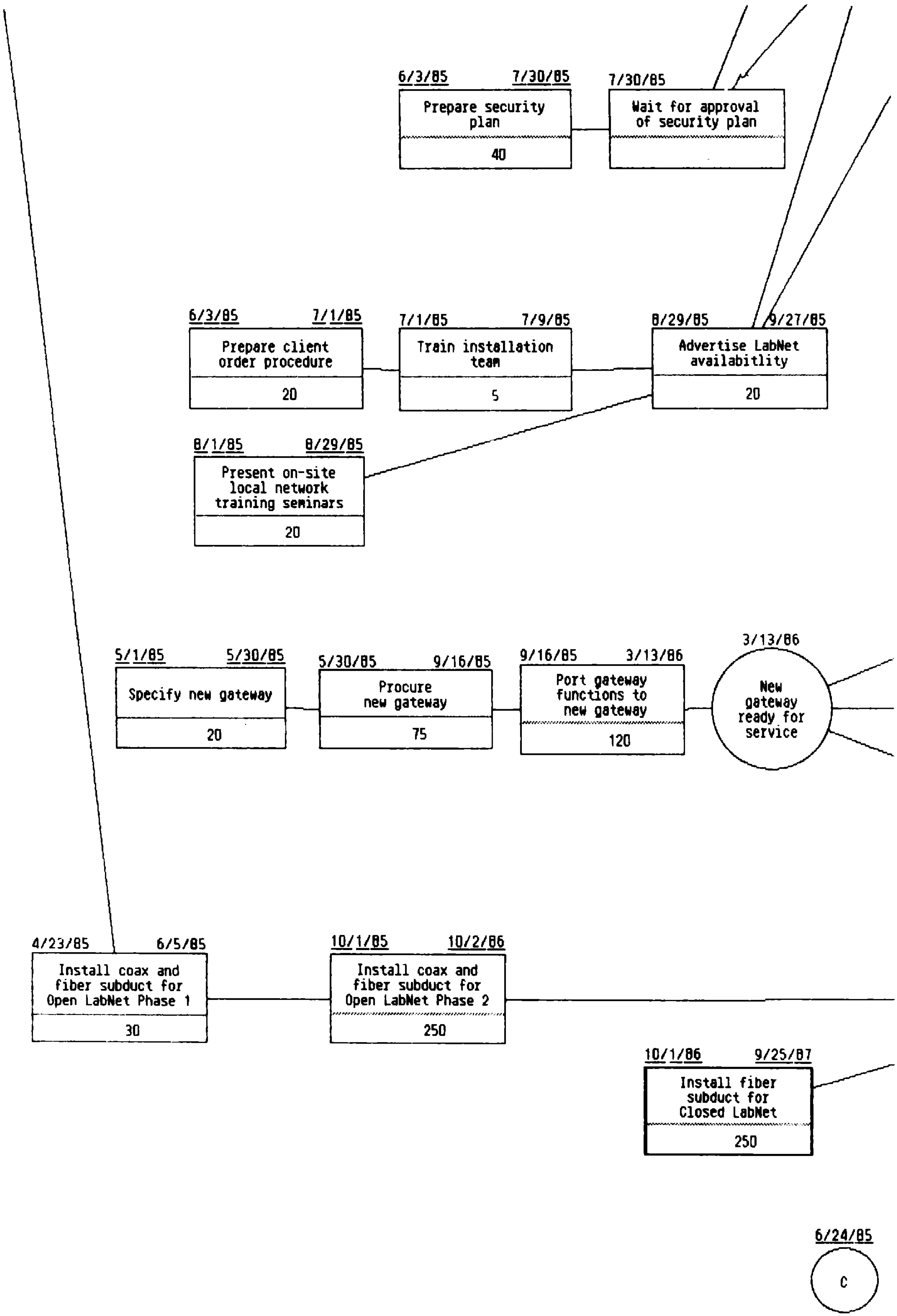
A

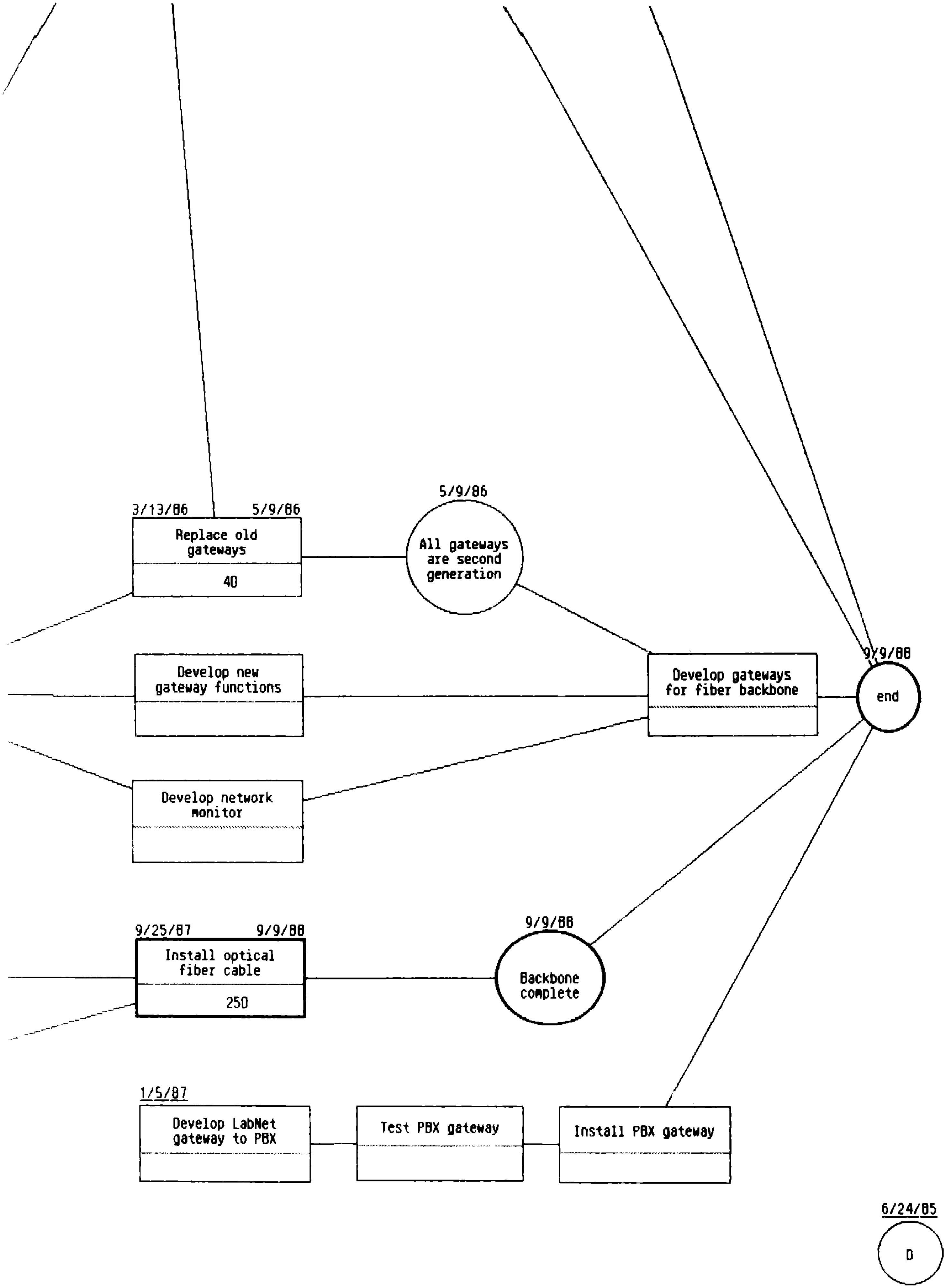
LabNet

Schedule Chart



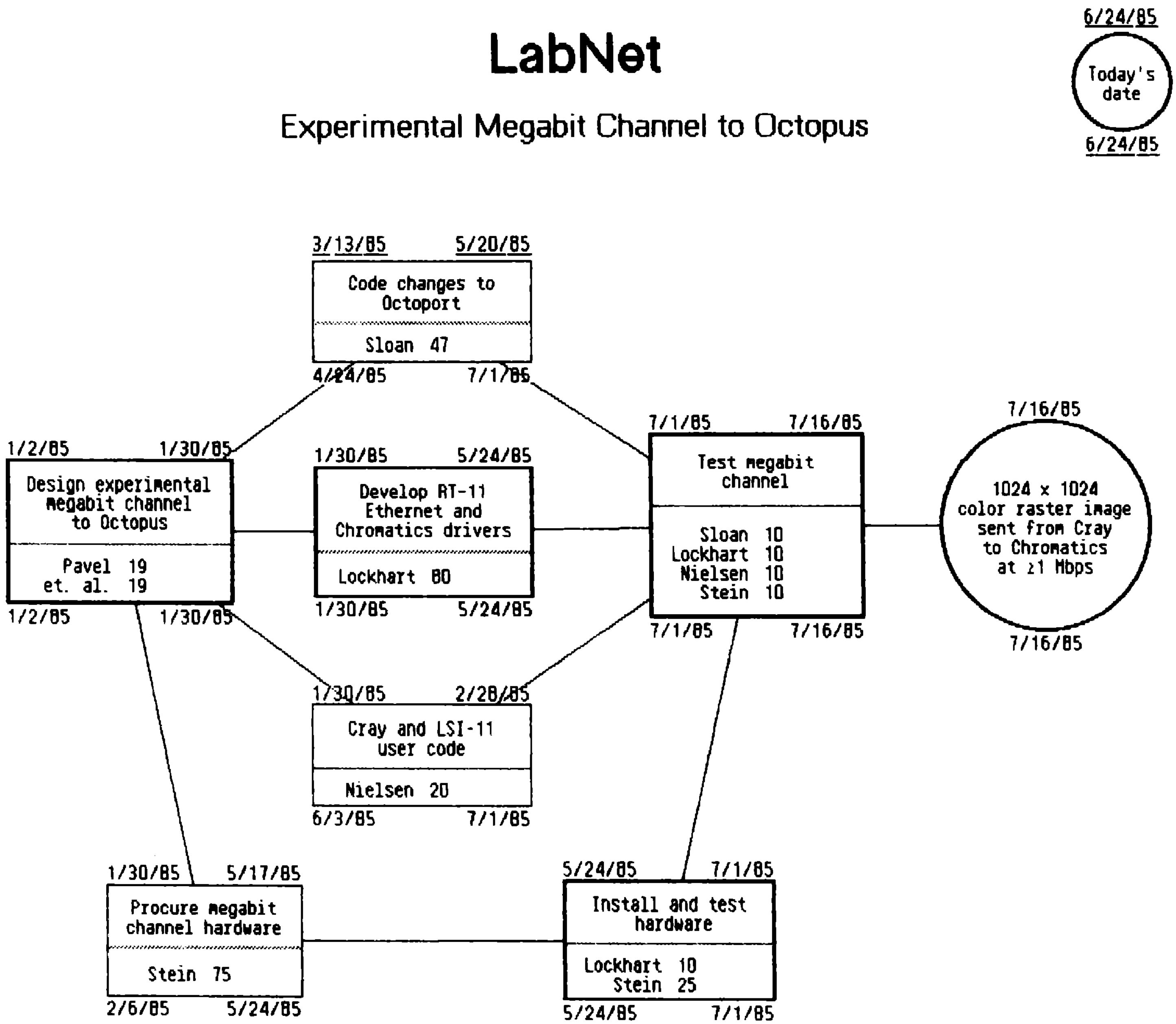

6/24/85
B
9/27/85
Open LabNet ready for service
10/11/85
CYB gateway code frozen
9/27/85
Closed LabNet ready for service


6/3/85
7/30/85
Prepare security plan
40
7/30/85
Wait for approval of security plan
6/3/85
7/1/85
Prepare client order procedure
20
7/1/85
7/9/85
Train installation team
5
8/29/85
9/27/85
Advertise LabNet availabitlity
20
8/1/85
8/29/85
Present on-site local network training seminars
20
5/1/85
5/30/85
Specify new gateway
20
5/30/85
9/16/85
Procure new gateway
75
9/16/85
3/13/86
Port gateway functions to new gateway
120
3/13/86
New gateway ready for service
4/23/85
6/5/85
Install coax and fiber subduct for Open LabNet Phase 1
30
10/1/85
10/2/86
Install coax and fiber subduct for Open LabNet Phase 2
250
10/1/86
9/25/87
Install fiber subduct for Closed LabNet
250
6/24/85
C


3/13/86
5/9/86
Replace old gateways
40
5/9/86
All gateways are second generation
Develop new gateway functions
Develop gateways for fiber backbone
9/9/88
end
Develop network monitor
9/25/87
9/9/88
Install optical fiber cable
250
9/9/88
Backbone complete
1/5/87
Develop LabNet gateway to PBX
Test PBX gateway
Install PBX gateway
6/24/85
D

LabNet

Experimental Megabit Channel to Octopus



7.0 Project Costs

LabNet Development Costs

	Pre FY85	FY85	FY86	FY87	FY88	All Years
Open LabNet backbone	100	121	480	570	570	1,841
Closed LabNet backbone		10	575	500	500	1,585
Gateways	62	121	310	425	300	1,218
Software licenses		50				50
Development equipment	135	27	75			237
Network management equipment	36	19	50	50		155
Miscellaneous	20	20	40	40	40	160
Equipment Total	353	368	1,530	1,585	1,410	5,246
Manpower	640	890	980	830	650	3,990
Training and travel	10	10	10	10	10	50
Manpower Total	650	900	990	840	660	4,040
Total	1,003	1,268	2,520	2,425	2,070	9,286

These numbers represent the cost of developing LabNet into a useful communication utility. They do not reflect the cost of maintaining the network after it is in production. Maintenance costs will be described in a later revision of this plan. All figures are in thousands of dollars. Costs for FY 1985 and before reflect actual amounts spent or planned.

FY 1986 figures for backbone cable installation are largely composed of pending general plant requests. For Open LabNet, the $480K covers the installation of two coaxial cables and an optical fiber subduct to 23 buildings. For Closed LabNet, $575K is an estimate of the cost to retrofit optical fiber subduct into the classified ducts. Backbone costs for FY 1987 and FY 1988 are for the installation of optical fiber cable. If general plant funds are not available for any of these installations, individual programs will have to fund the extension of LabNet to their buildings.

The cost for gateways from FY 1986 on are based on an estimated price of $10,000 per gateway. The price should drop over the years. Each program pays for its own gateways.

Software licenses and development equipment cover those items required for the programmers to develop code for the gateways and for the client's system. Network management equipment includes diagnostic instruments and network configuration, and monitoring systems. The miscellaneous category covers small items and other operating costs.

Manpower figures are based on $100K per FTE. Four FTEs are allocated to LabNet from the Computation Department New Initiatives Program. Another full FTE is used for technical support by the Computation Engineering Group in the Electronics Engineering Department. The rest of the manpower cost covers partial FTEs for programmers and engineers who work on LabNet tasks.

Training and travel is an estimated cost for project team members to attend conferences, seminars, and vendor factory visits.

Appendix A

Terminal Switching System

The need for a mechanism that allows a person to have only one terminal in his office, yet be able to connect to more than one computer is evident. (For unclassified systems, modems used over dial-up telephone lines are the mechanism. But modems only allow data rates up to 2400 bps, and dialing up should not be necessary on the Laboratory site.) The first problem is accessing classified and unclassified systems with the same terminal; security requirements make this difficult and, in fact, do not allow such access if the terminal has local storage. The second problem is finding the best way to wire the terminals and systems together.

The classified/unclassified switching problem is more of a policy issue than a technical one. An approved mechanical switch is being investigated so that a terminal can be switched between any two computers. A more general solution is an approved computer controlled switch that can interconnect any terminal to any computer. Even if classified/unclassified switching is not allowed, this general solution is desirable since many users need access to more than one computer.

The other problem, then, is how to implement the general switch. There are three approaches:

1. Port contention switches

2. Local area network terminal interfaces

3. Digital PBX

Port contention switches are specifically designed to switch terminals to computer ports. All terminals and computer ports are cabled directly to the switch. The maximum data rate for any connection is usually 9600 bps; some switches go as high as 19,200 bps.

Local area network interfaces distribute the switching function to devices co-located with the terminals and computer ports. One interface can connect up to 64 terminals or ports to the local network. A conversation between a terminal and a computer port is packetized when transmitted over the network. Since the data rate of the network is much greater than that of a terminal, this packetization is not usually noticed. Maximum data rates for a connection are typically 19,200 bps.

Digital PBXs (Private Branch Exchanges) are designed for switching digitized voice signals for telephone systems so they have a very high internal bandwidth. Since all signals and controls are digital, they are suitable for switching data as well as voice. Cabling for a PBX is central as with port contention devices, although newer models allow distributed switching nodes connected with high-speed links. Digital PBXs can easily accommodate data rates up to 64 Kbps, some claim rates over 1 Mbps.

Which approach is best for the Laboratory? The question is not easy to answer. Port contention switches are the cheapest per terminal and have the most mature technology, but they have a limit on data rates that would be difficult to increase, and they require a large central facility. Local area network interfaces are more modern, offer reasonable data rates that could easily be increased, and do not require a central facility; but they are more expensive, and, when loading on the network is heavy, the delays due to packetization are noticeable. Digital PBXs offer very high data rates and moderate cost if data switching features are simply added to a PBX used for voice. They are very expensive if acquired solely to do terminal switching. No single approach has all the advantages.

A mixture of the choices is a reasonable plan. A port contention switch or a PBX could be located in a building with all terminals and computers in the building wired to it. The switch would connect to LabNet. All switching within the building would be handled by the port contention switch or PBX. Connections outside the building would be made over LabNet. This requires the definition and implementation of a suitable LabNet interface.

Alternatively, if a building is already wired with a local network, terminals can be switched with local network interfaces to avoid the cost of putting in extra wiring just for the terminals. If a connection outside the building is required, it can be made through a computer on the local network over LabNet.

The Laboratory will be replacing its telephone system over the next few years with a digital PBX. The data switching features added to the PBX should meet most unclassified terminal switching requirements at a reasonable cost. A gateway between the PBX and the Open LabNet packet channel will be developed. The availability of a PBX at the Laboratory will make port contention devices for unclassified systems superfluous, but local area network interfaces would still be a reasonable alternative for buildings with local networks.

For classified systems, a likely choice is to duplicate the ports of the PBX required for data switching. This is expensive, but it offers a commonality of ports and cabling with the unclassified system and the user interface is the same. The centralized cabling scheme for classified terminals is already in place with the Octopus terminal wiring.

Appendix B

Communications Protocols

A data communications protocol is a set of rules for exchanging information between computers. It specifies how the data is to be packaged and the handshaking required to assure a correct exchange. The International Standards Organization (ISO) has specified a way of organizing communications between computers called the Open Systems Interconnect (OSI) model, which describes a seven-layer hierarchy of communications protocols. The model describes abstractly what each layer is supposed to do, but not how to do it. The ISO and others are working on standards that define concretely what services each layer performs and what the protocol for each layer actually looks like.

Figure B1 is a schematic that shows how two systems that conform to the OSI model communicate.

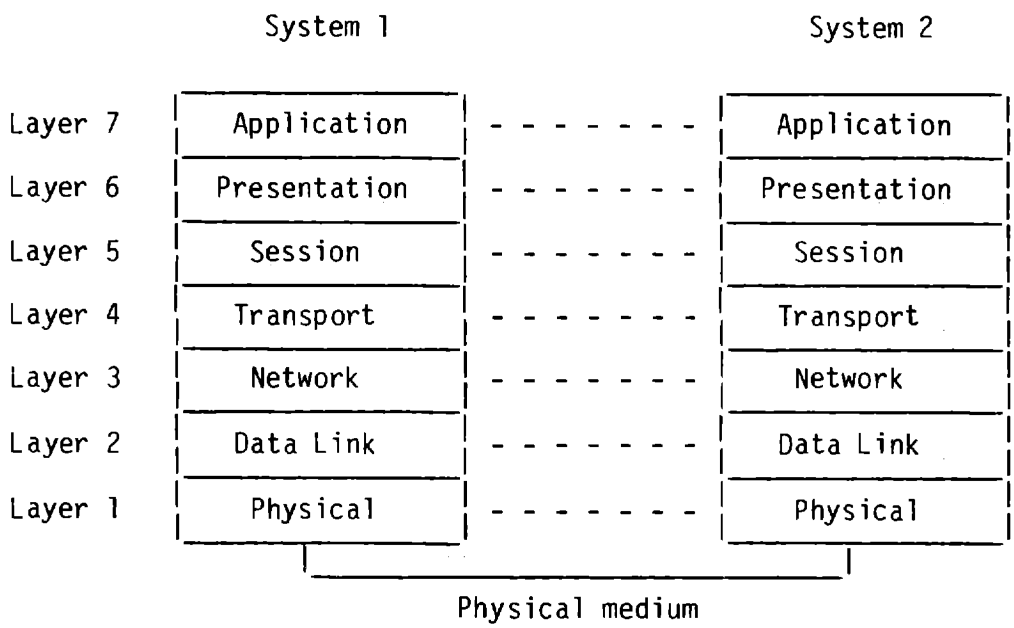


Figure B1

Each layer in one system communicates with its counterpart in the other system using a peer protocol defined for that layer; this is indicated by the dotted lines in the figure. The actual path for this communications, however, is down through succeedingly lower layers in one system, over the physical medium that connects the two systems to the other one, and then up the layers there. Each layer provides services to the layer above it by using the services of the layer below it. The functions of each layer are:

Application Layer (7) - provides the interface to the user of the communications services

Presentation Layer (6) - performs code and format translations (for example, converting ASCII to EBCDIC)

Session Layer (5) - synchronizes the dialogue between two systems; more than one dialogue, or session, can be active at the same time

Transport Layer (4) - provides for transparent transfer of data; manages the end-to-end data flow

Network Layer (3) - routes the data from one end system to another by selecting the appropriate physical connection; the data may be relayed through intermediate systems

Data Link Layer (2) - moves data from one system to another which is physically connected to it

Physical Layer (1) - describes the mechanical and electrical means to transmit data bits over the physical medium

Transfer of data between two systems is done by bunching it into packets which can be separately transmitted. By interleaving packets, several systems can use a common physical medium simultaneously. This is called packet-switching.

To implement peer protocols, a layer must transmit some control information to its counterpart along with the data. As the data moves down through the layers, each layer adds its own control information; as the data moves up through the layers, the control information is stripped off. The control information is usually prepended to the data packet to form a slightly larger packet. The appearance of a packet at each layer is diagrammed in Figure B2.

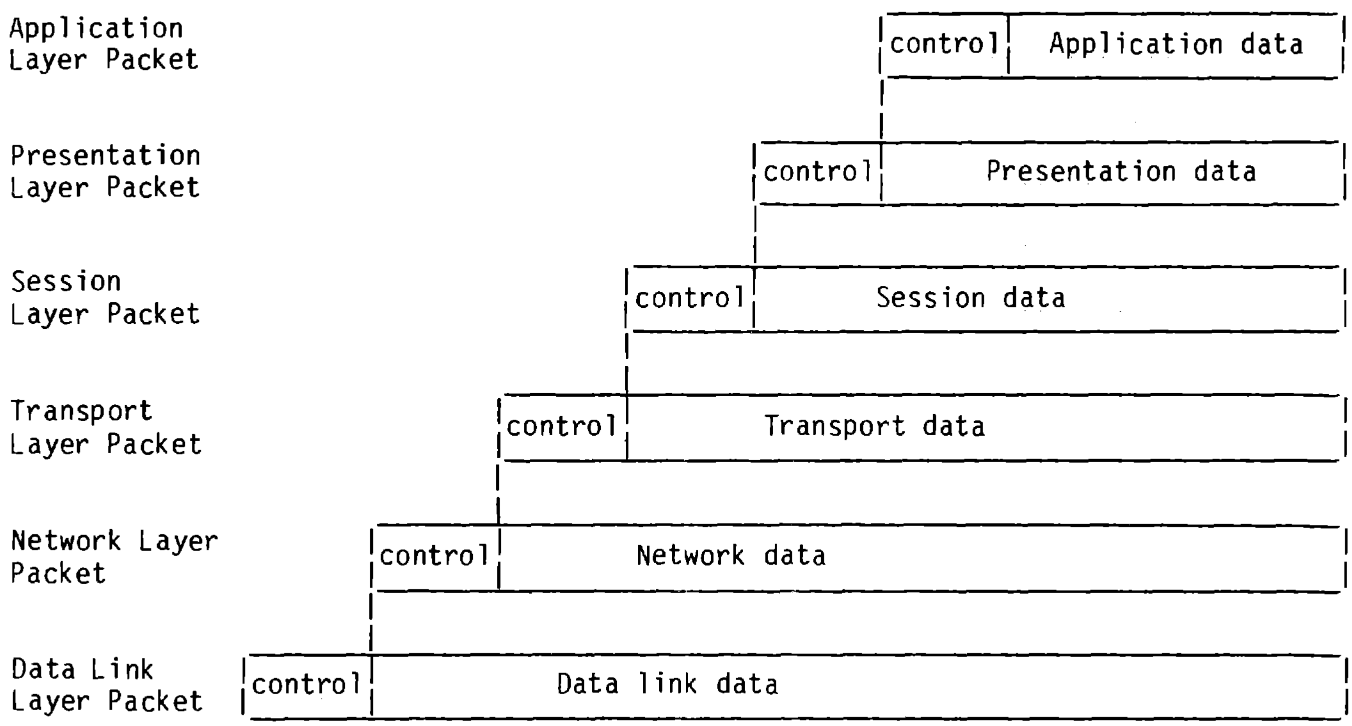


Figure B2

Note that the full packet at one layer becomes the data portion of the packet at the next lower layer. A layer does not interpret or modify the data portion of its packet.

Included in the control information in the network layer are addresses that identify the source and destination of the packet. Network layer addresses are unique for every entity that uses the same network layer protocol. There may be more than one such entity within each OSI system.

When more than two devices share the same physical medium, as in a local network like Ethernet, the data link layer also has addresses as part of its control information. These addresses uniquely identify the devices using the medium. In general, there is no relationship between the data link and the network layer addresses.

The uniqueness of data link layer address on a local network is easy to insure since the network is geographically limited and has a relatively small number of devices attached to it. At the network layer, however, there is no geographic limit, and the number of entities can be huge. This creates a problem of how to manage the allocation of global addresses. The ISO has developed a scheme to allocate addresses for the network layer protocol it is standardizing. Until this protocol is accepted world-wide, others will have to worry abut different protocols. LabNet will manage assignment for all LINCS addresses at the Laboratory.

When two systems are not connected together directly, but are separated by a relay system, the schematic for communication is as shown in Figure B3. The relay system could consist of a single computer or one or more networks of computers.

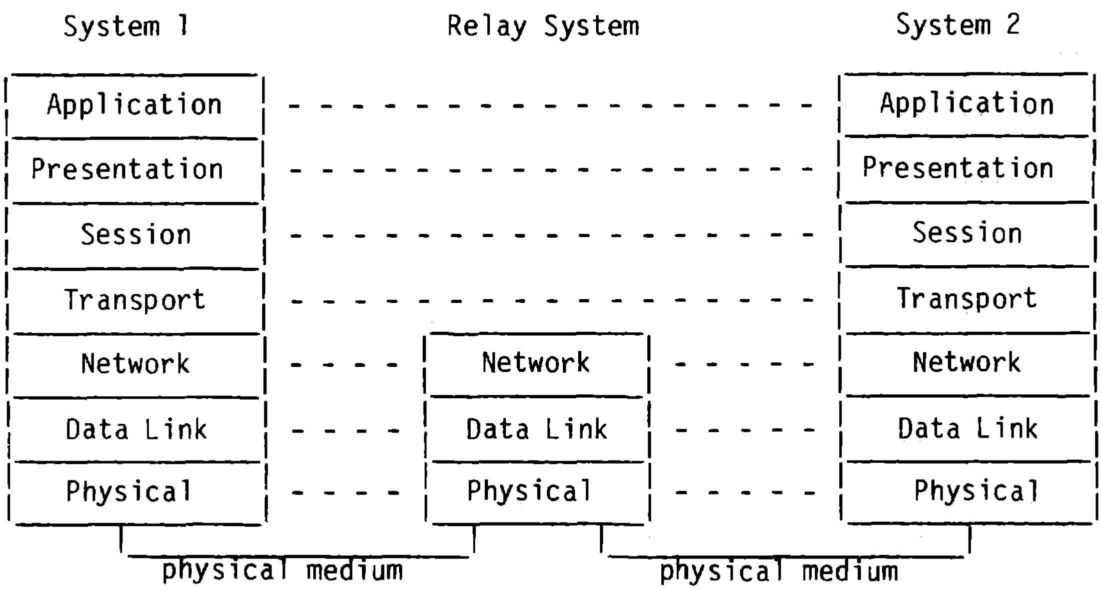


Figure B3

Peer protocols operate as before, but the path for communications is down through the layers in one system, over a physical medium to the relay system, up the layers there and then back down again to go out over another physical medium to the destination system. Note that the relay system does not have to implement all the layers. The simplest relay works only at the network layer to route data to its destination. The end systems have to be using the same protocols from the network layer up through the application layer, but may use different data link and physical layers since the relay sits between them. Relays that implement more layers are possible. A relay that implements all seven layers can connect two systems that use completely different protocols; this type of relay is a translating system. The LabNet packet-switched channel is a relay system at the network layer that implements more than one network layer protocol.

Full seven-layer protocol implementations are offered by various vendors and organizations. The three that are most widely used at the Laboratory are:

1. DECNET - used by most of the DEC VAX computers in the Engineering departments

2. TCP/IP - DOD standard used on ARPANET and by many computers and scientific workstations that run the UNIX operating system

3. LINCS - protocols developed by the Computation Department for the efficient use of the Cray supercomputers in the LCC and other computers connected to them.

These protocols are incompatible. Even two computers that are connected to the same local network and, therefore, use the same physical and data link layer implementations, cannot communicate between applications if they do not use the same protocol for the higher layers.

Appendix C

Closed LabNet Buildings

111	113	115	116	121	1279	131
151	2106	218	2580	311	316	321
381	482					

Open LabNet Buildings

111	113	116	117	121	1279	131
141	1452	151	1677	1705	194	2102
2106	212	217	216	217	218	222
231	235	2428	253	2580	2625	281
2825	311	314	315	321	3576	3701
381	391	4106	411	4180	4182	439
4440	451	481	482	511	517	543
5475	551	9141				